

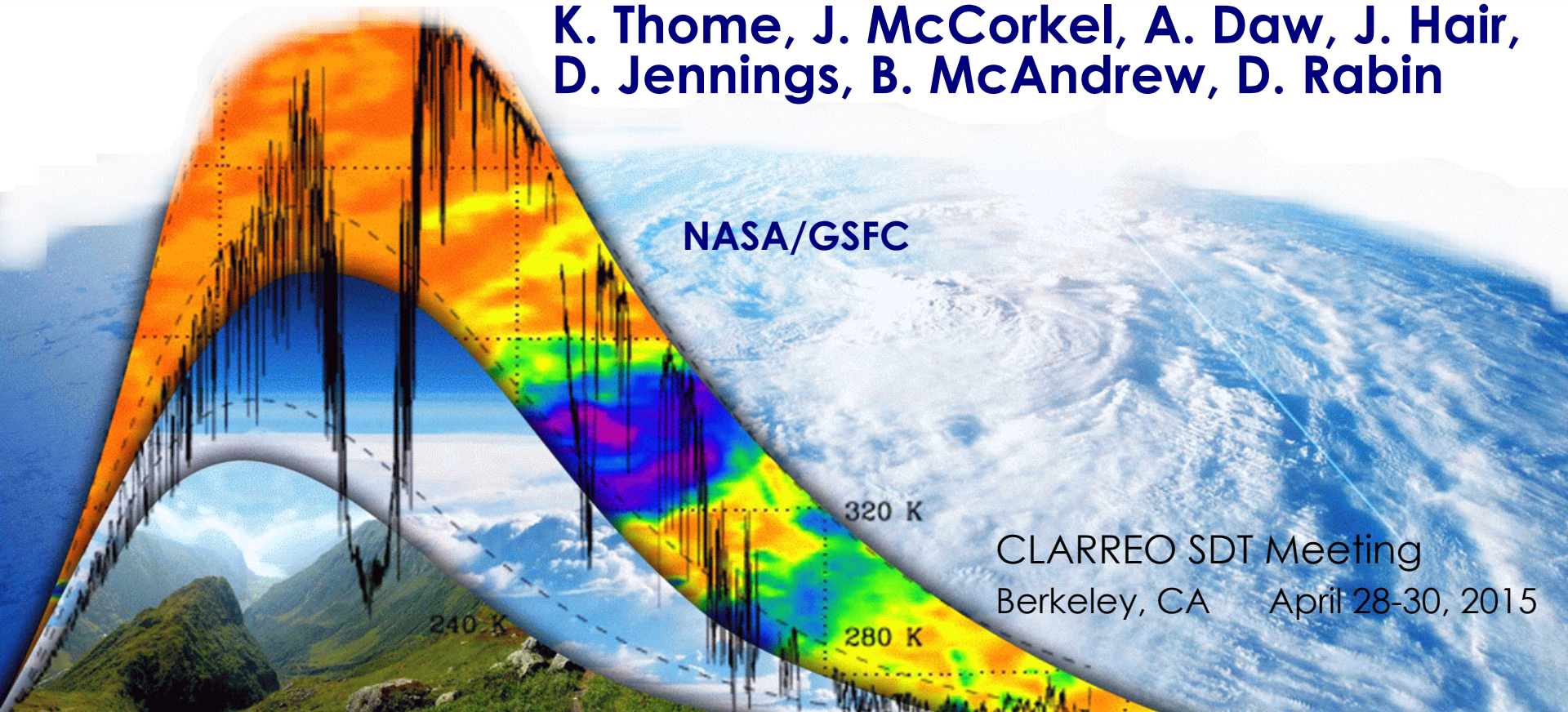


GODDARD SPACE FLIGHT CENTER

# GSFC RS Calibration Demonstration System

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NASA/GSFC



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# CLARREO RS GSFC Overview

Past nine months has seen work on both Calibration Demonstration System (CDS) as well as Pathfinder efforts

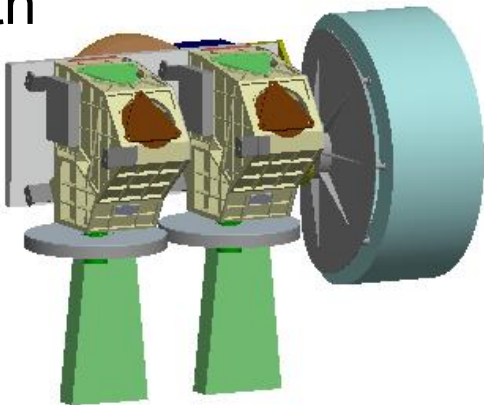
- Highlight of CDS efforts was a collaboration with the Joint Polar Satellite System
  - Organized NIST work for calibration of Visible Infrared Imaging Radiometer Suite
  - Updated calibration hardware to improve automation and repeatability
- Field campaign in collaboration with Landsat mission



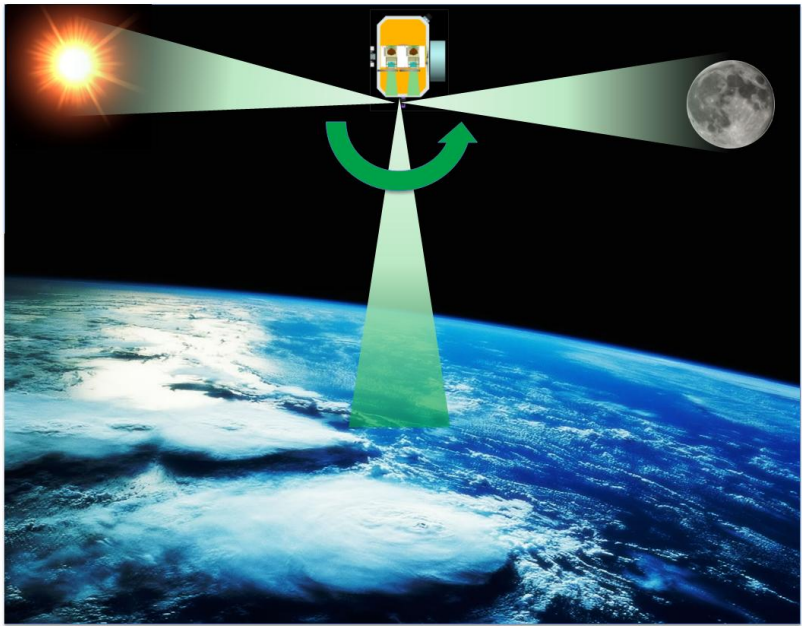
# Reminder - RS Instrument

Offner system covering 320 to 2300 nm with 500-m GIFOV and 100-km swath width

Reflectance traceable to SI standards at an absolute uncertainty <0.3%

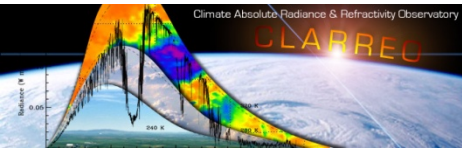
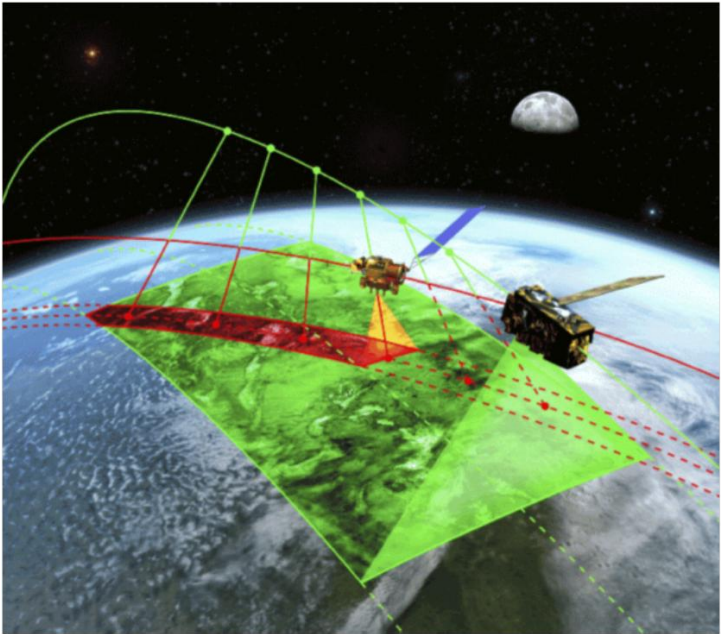


Benchmark reflectance from ratio of earth view to measurements of irradiance while viewing the sun

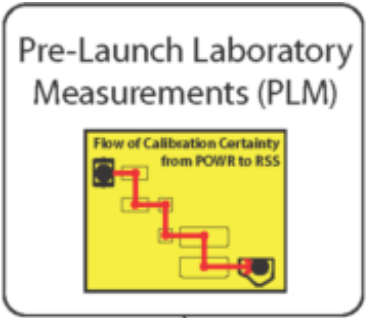


Lunar data provide calibration verification

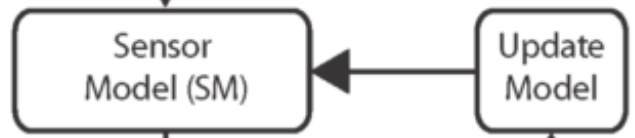
Intracalibration plays a key role in developing climate record



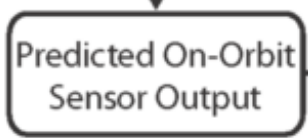
# Pathfinder will demonstrate calibration approach



Characterize sensor to SI-traceable, absolute radiometric quantities during prelaunch calibration



Component and system level data used to develop hi fidelity sensor model

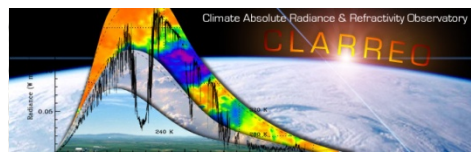


Calibration Circuit



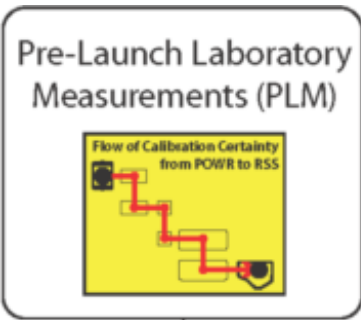
Transfer to orbit through accurate prediction of sensor behavior while viewing known sources

Ensure prelaunch calibration simulates on-orbit sources



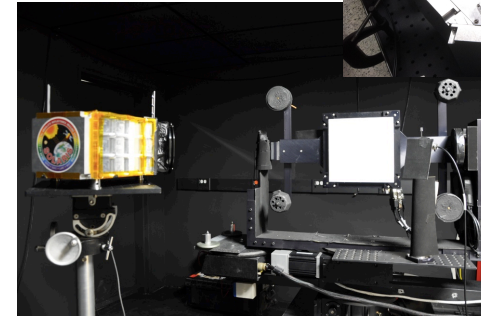
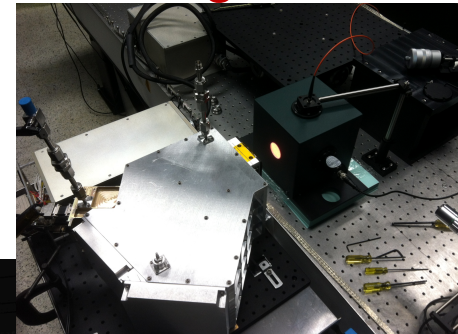
# SOLARIS CDS testing overview

Follow calibration plan for CLARREO with emphasis on radiometric and spectral calibrations, sensor stray light, and optical modeling



## Laboratory Calibration

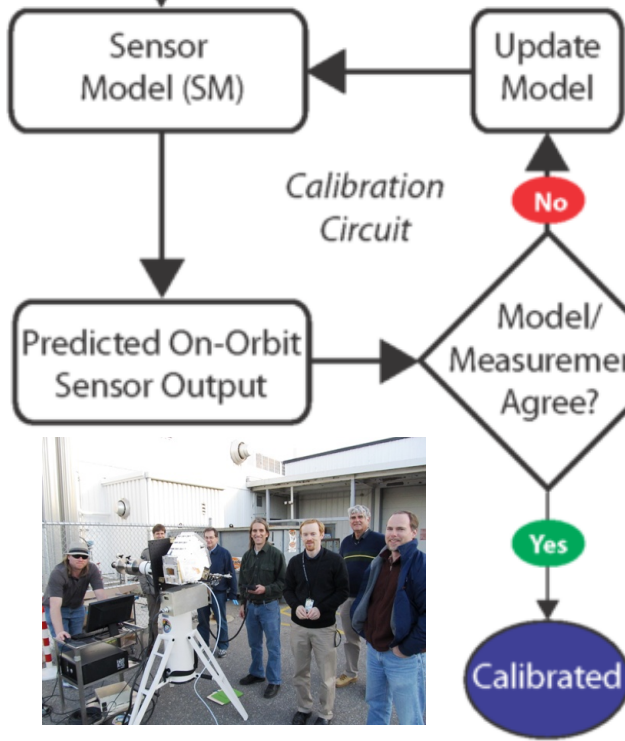
High-accuracy, SI-traceable, detector-based, absolute radiometric



## Sensor Model

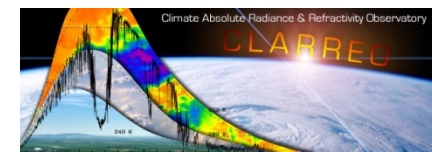
Developed from component and system level data

Calibration Circuit



## Field collections

To understand on-orbit approaches

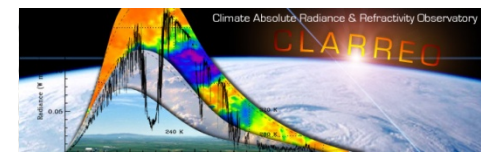
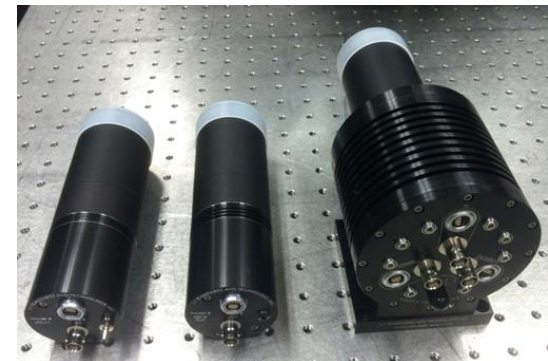
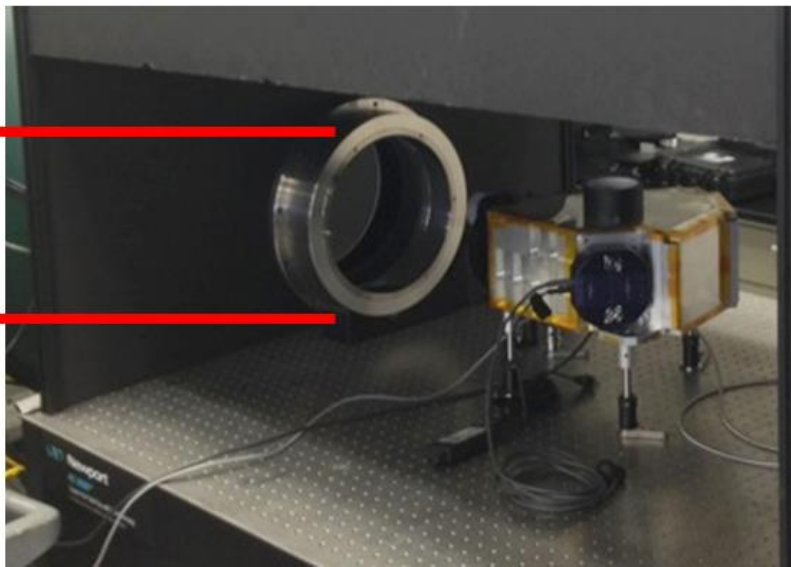
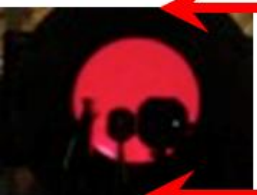
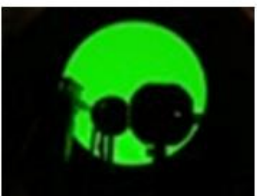
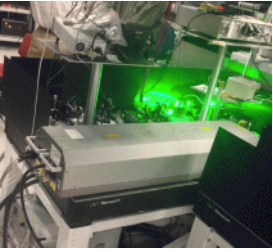




# RS CDS Laboratory work

## Small steps leading to significant progress

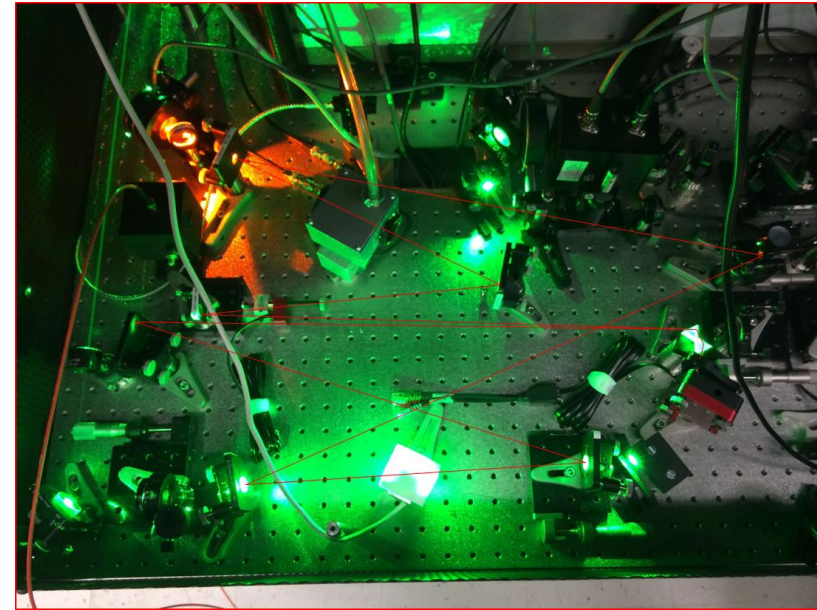
- GSFC SIRCUS calibration relies on a tunable laser source calibrated using accurate and stable detectors calibrated at NIST
  - LASP approach uses a cryogenic, electric substitution radiometer for its traceability
  - Good example of benefits of multiple groups working the same problem in different ways



# SIRCUS in the laboratory

## Collaboration with NIST continues to be strong

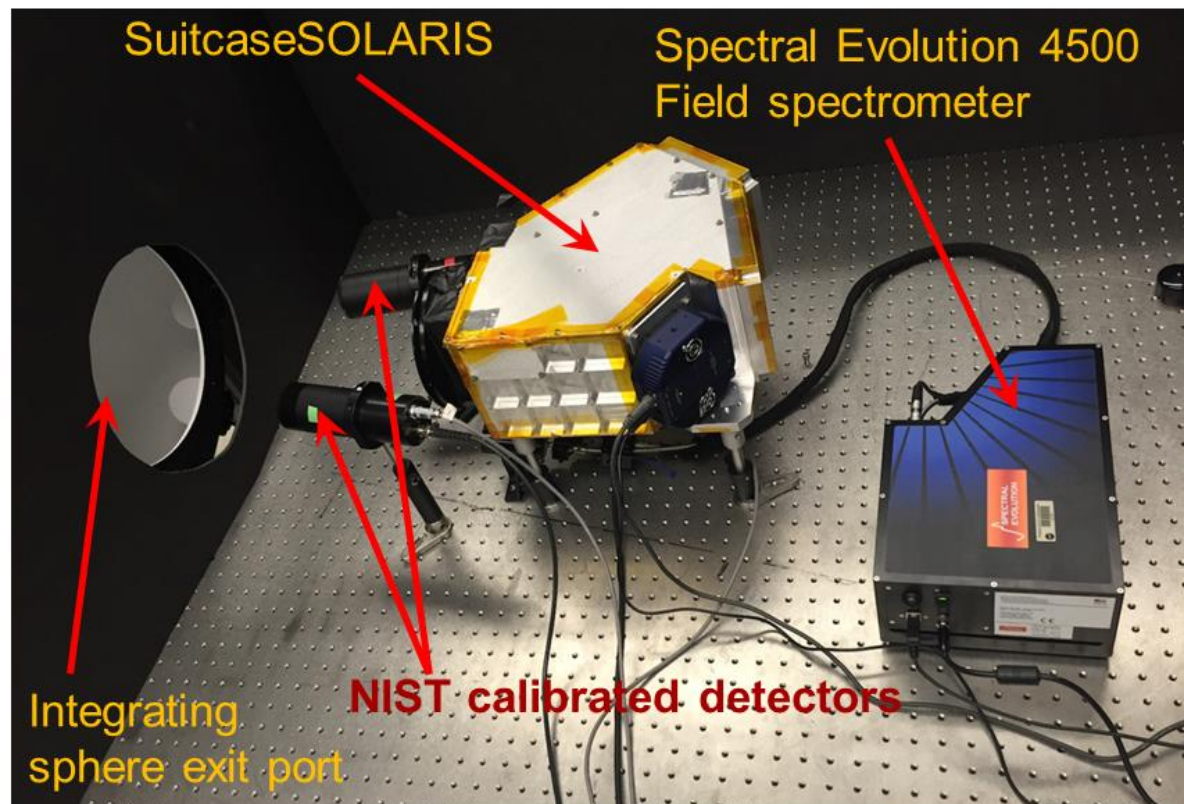
- Automated laser spectral tuning was demonstrated
  - Streamlining tuning ranges
  - Improving wavelength stability
- Keith Lykke (NIST) and SOLARIS team implemented tunable laser as a first step to fill gaps in spectral output
  - Relies on better thermal control of optical systems
  - Note the “orange” output from the “green” source



# SuitcaseSOLARIS radiometric calibration

Began intercomparisons of silicon trap detectors needed to maintain SI-traceability

- SuitcaseSOLARIS fully calibrated using SIRCUS lasers and silicon trap radiometers
- Round-robin planned with NIST based on these data
- Provides the SI-traceability needed for the March field campaign





# March 2015 Field Work

## Field campaign to Algodones Dunes in southern California March 8-12

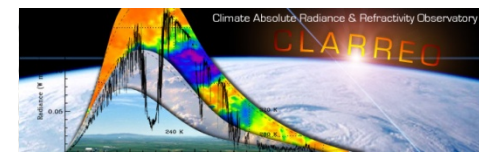
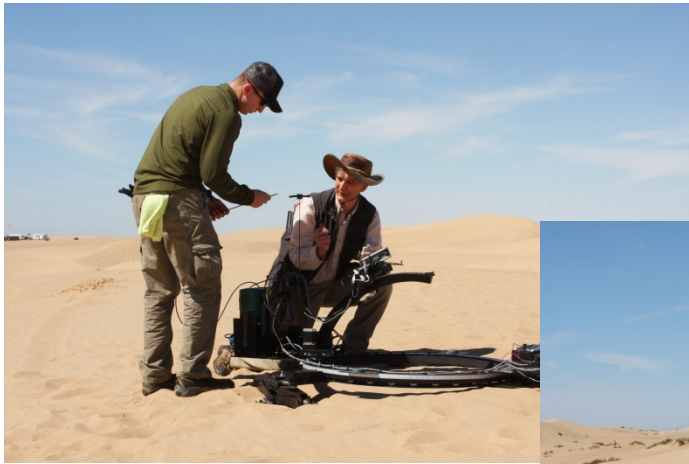
- Dunes are used for the radiometric calibration of imaging sensors
- Measurements were timed to coincide with Landsat 7, Landsat 8 and Worldview 3 satellite measurements for intercomparison studies



# March 2015 field work

Joint campaign with four other groups to assess surface properties of the dunes

- Univ. of Arizona
- South Dakota State University
- Rochester Institute of Technology
- University of Lethbridge

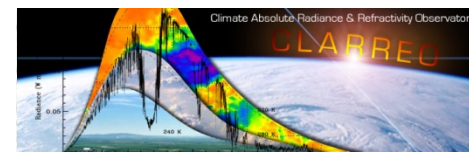
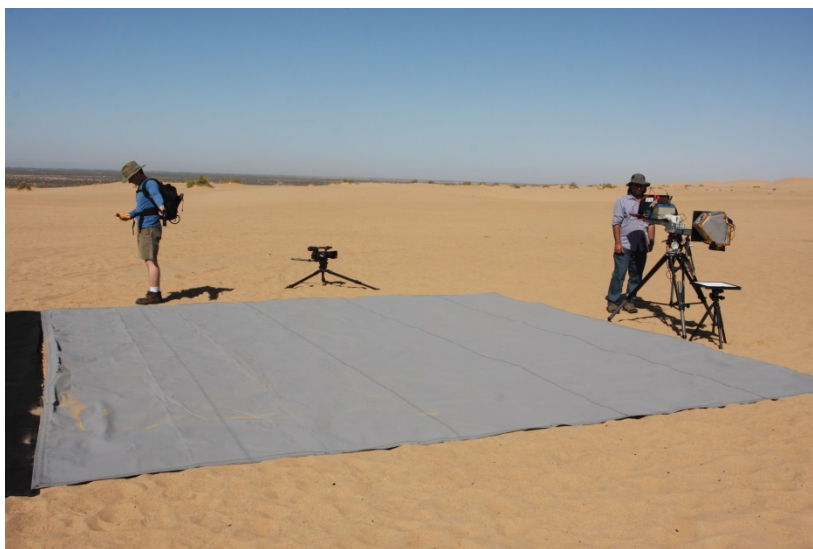




# SOLARIS and field work

RS CDS efforts included ground and airborne instruments

- Goddard airborne imaging spectrometer calibrated in the CLARREO CDS facility
- SOLARIS on the ground
- Even had communications team documenting the effort

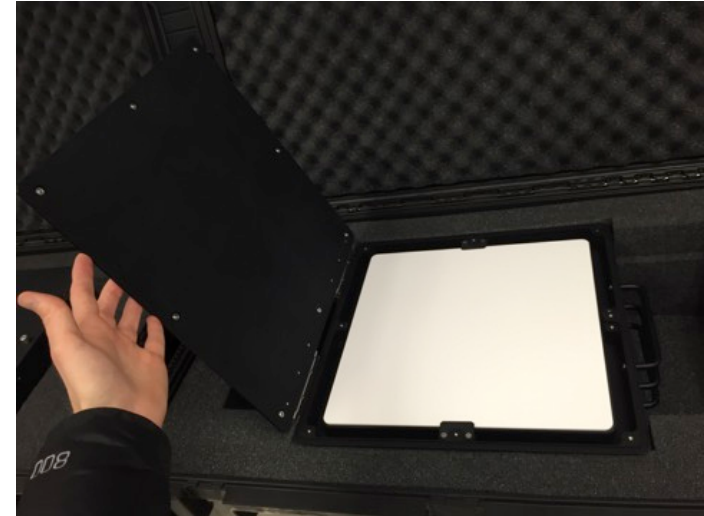




# Field testing SOLARIS laboratory calibration

One goal is to demonstrate the accuracy of CLARREO reflectance calibration

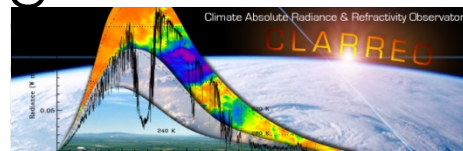
- SOLARIS pathway includes known standards within the image while operating outdoors
- Six 12-inch Spectralon panels were sent to University of Arizona for bidirectional reflectance characterization in the 350-2500 spectral region
  - UofA has provided NIST-traceable reflectance characterization for numerous flight missions
  - UofA has demonstrated  $<1.5\%$  ( $k=2$ ) uncertainty through NIST round-robin activities



# The SIRCUS went to California

NIST and GSFC participated in post-TVAC testing of VIIRS from Oct. to Dec. 2015

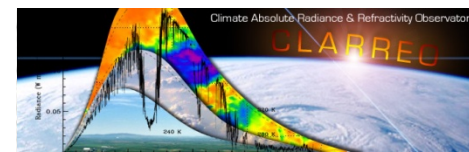
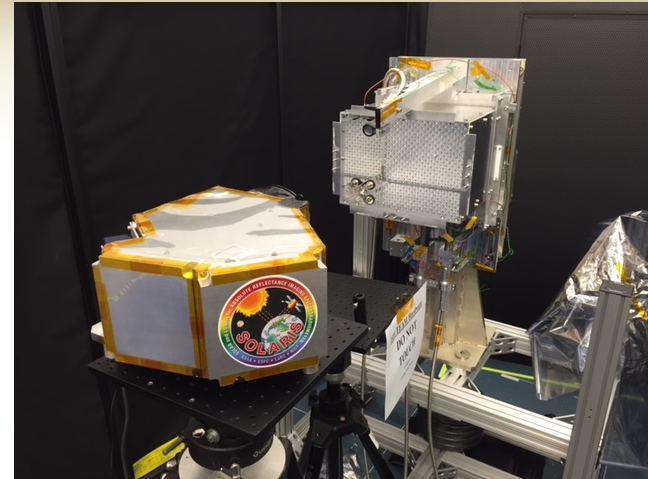
- Took place at the Raytheon SAS facility in El Segundo
  - McCorkel and McAndrew from GSFC
  - Brown and Lykke from NIST
- SIRCUS set up took place in November 3-13
  - Calibrated Raytheon integrating sphere
  - Worked with Raytheon to finalize measurement plans
- SIRCUS testing was conducted December 5-11
- Methods and procedures developed will be the basis for CLARREO pre-launch testing



# SOLARIS and VIIRS calibration

SuitcaseSOLARIS was included in the VIIRS testing with a Flat-Plate Illuminator

- NIST developed the FPI to provide a thermal vacuum-compatible radiance source
- Used for VIIRS as a trending source
- SuitcaseSOLARIS measured the FPI at three output levels with three integration time configurations
  - NIST will supply the CLARREO team with FPI output values
  - Compare NIST-supplied radiance with SuitcaseSOLARIS results





# FY15 Plan

## Complete extension of calibration scales to 1.6 micrometers and near-IR transfer radiometer calibration at NIST

- Developing test plan with NIST for JPSS-2 VIIRS calibration to include channels  $> 1.0$  micrometers
  - Will help to formalize NIST detector calibrations at longer wavelengths
  - Lead to filling “gaps” in laser output
  - Incorporation of SWIR-capable laser in SOLARIS facility
- Refine automated wavelength tuning leading to a operational version of SIRCUS
- Calibrations closure on Landsat field campaign data
- Renew measurements of solar and lunar irradiance

# FY16 Plan

## RS Collaboration with NIST to extend calibration scale to 2.3 micrometers

- Implementation of NIST-calibrated reflectance standard to evaluate uncertainties
- RS Instrument model development will continue
- Further measurements of solar and lunar irradiance in addition to field deployments
- Repeatability of lunar retrievals
- Absolute measurement of solar irradiance

